Claims

What is claimed is:

1. A method of controlling a semiconductor manufacturing tool using a feedback control mechanism, comprising:

(a) receiving a plurality of data points relating to an output of the tool including a current data point and at least one previous data point;

(b) determining whether the current data point is an outlier based on:

(b-1) comparing the current data point to a statistical representation of the at least one previous data point; and

(b-2) whether the at least one previous data point is an outlier; and

(c) disregarding the current data point in calculating a feedback value of the feedback control mechanism if the current data point is determined as an outlier.

2. The method of claim 1, wherein (b) further comprises:

determining the current data point as an outlier only if the at least one previous data point is not an outlier.

3. The method of claim 1 or 2, further comprising:

(d) calculating the feedback value of the feedback control mechanism using the current data point and the at least one previous data point if the current data point is determined as not an outlier.

4. The method of claim 1 or 2, further comprising:

(d) calculating a previous feedback value for the at least one previous data point and then calculating the feedback value based on the previous feedback value and the

current data point if the at least one previous data point is an outlier and the current data point is an outlier.

5. The method of claim 1 or 2, wherein the statistical representation of (b-1) is a weighted moving average of the at least one previous data point.

6. The method of claim 1 or 2, wherein the statistical representation of (b-1) is an exponentially-weighted moving average of the at least one previous data point.

7. The method of claim 1 or 2, wherein the statistical representation of (b-1) is expressed as:

$$S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$$

where,

β is a coefficient;

F_k is the difference between the current data point and predicted values for wafer *k*; and

Δ_k is a feedback value for time *k*.

8. The method of claim 7, wherein the value of Δ_k is calculated as:

$$\begin{aligned} &if \left|F_k - \Delta_k\right| \le K_n s_k \\ &\quad \Delta_{k+1} = \lambda_k F_k + (1-\lambda_k)\Delta_k \\ &else \\ &\quad \Delta_{k+1} = \Delta_k \end{aligned}$$

where, λ_k is a coefficient;

K_n is an outlier coefficient; and

$s_k = \sqrt{S_k}$.

9. The method of claim 7, further comprising:

updating S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$ when the current data point is determined as not an outlier.

10. The method of claim 7, further comprising:

updating S_k as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

11. The method of claim 6, further comprising:

updating S_k as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1-\beta)S_{k-1}$; and then

updating S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$, when the current data point is determined as not an outlier and the previous data was not determined as an outliner.

12. The method of claim 1 or 2, further comprising:

making a plurality of measurements on the output of the tool using at least one metrology station; and

calculating the current data point based on the plurality of measurements.

13. The method of claim 12, further comprising:

calculating an interval based on statistical information relating to the plurality of measurements;

identifying a subset among the plurality of measurements that fall within the interval; and

calculating the current data point from the subset of the plurality of the measurements.

14. The method of claim 13, wherein the statistical information relates to at least one of a median and a standard deviation of the plurality of measurements.

15. The method of claim 14, further comprising:

calculating the standard deviation based on one of a variance and a scaled variance of the plurality of measurements.

16. A system of controlling a semiconductor manufacturing tool using a feedback control mechanism, comprising:

an estimator configured to receive a plurality of data points relating to an output of the tool including a current data point and at least one previous data point,

wherein the estimator is further configured to determine whether the current data point is an outlier based on comparing the current data point to a statistical representation of the at least one previous data point, and whether the at least one previous data point is an outlier, and

wherein the estimator is further configured to disregard the current data point in calculating a feedback value of the feedback control mechanism if the current data point is determined as an outlier.

17. The system of claim 16, wherein the estimator is further configure to determine the current data point as an outlier only if the at least one previous data point is an outlier.

18. The system of claim 16, wherein the estimator is further configured to calculate the feedback value of the feedback control mechanism using the current data point and the at least one previous data point if the current data point is determined as not an outlier.

19. The system of claim 16, wherein the estimator is further configured to calculate a previous feedback value for the at least one previous data point and then calculate the feedback value based on the previous feedback value and the current data point if the at least one previous data point is an outlier and the current data point is an outlier.

20. The system of claim 16, wherein the statistical representation of is a weighted moving average of the at least one previous data point.

21. The system of claim 16, wherein the statistical representation of is an exponentially-weighted moving average of the at least one previous data point.

22. The system of claim 16, wherein the statistical representation of is expressed as:

$$S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$$

where,

β is a coefficient;

F_k is the difference between the current data point and predicted values for wafer *k*; and

Δ_k is a feedback value for time *k*.

23. The system of claim 22, wherein the value of Δ_k is calculated as:

$$\begin{aligned} &if \left|F_k - \Delta_k\right| \le K_n s_k \\ &\quad \Delta_{k+1} = \lambda_k F_k + (1-\lambda_k)\Delta_k \\ &else \\ &\quad \Delta_{k+1} = \Delta_k \end{aligned}$$

where, λ_k is a coefficient;

K_n is an outlier coefficient; and

$s_k = \sqrt{S_k}$.

24. The system of claim 22, wherein the estimator is further configured to update S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$ when the current data point is determined as not an outlier.

25. The system of claim 22, wherein the estimator is further configured to update S_k as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

26. The system of claim 22, wherein the estimator is further configured to update

S_k as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1-\beta)S_{k-1}$; and

S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$, when the current data point is determined as not an outlier and the previous data was not determined as an outliner.

27. The system of claim 16, further comprising:

at least one metrology station configured to make a plurality of measurements on the output of the tool, wherein the estimator is further configured to calculate the current data point based on the plurality of measurements.

28. The system of claim 27, the estimator is further configured to calculate an interval based on statistical information relating to the plurality of measurements, configured to identify a subset among the plurality of measurements that fall within the interval, and

configured to calculate the current data point from the subset of the plurality of the measurements.

29. The system of claim 28, wherein the statistical information relates to at least one of a median and a standard deviation of the plurality of measurements.

30. The system of claim 29, the estimator is further configured to calculate the standard deviation based on one of a variance and a scaled variance of the plurality of measurements.

31. A system of controlling a semiconductor manufacturing tool using a feedback control mechanism, comprising:

(a) means for receiving a plurality of data points relating to an output of the tool including a current data point and at least one previous data point, where in the at least one previous data point is received before the current data point;

(b) means for determining whether the current data point is an outlier based on:

(b-1) comparing the current data point to a statistical representation of the at least one previous data point; and

(b-2) whether the at least one previous data point is an outlier; and

(c) means for disregarding the current data point in calculating a feedback value of the feedback control mechanism if the current data point is determined as an outlier.

32. The method of claim 31, further comprising:

means for determining the current data point as an outlier only if the at least one previous data point is an outlier.

33. The system of claim 31, further comprising:

(d) means for calculating the feedback value of the feedback control mechanism using the current data point and the at least one previous data point if the current data point is determined as not an outlier.

34. The system of claim 31, further comprising:

(d) means for calculating a previous feedback value for the at least one previous data point and then calculating the feedback value based on the previous feedback value and the current data point if the at least one previous data point is an outlier and the current data point is an outlier.

35. The system of claim 31, wherein the statistical representation of is a weighted moving average of the at least one previous data point.

36. The system of claim 31, wherein the statistical representation of is an exponentially-weighted moving average of the at least one previous data point.

37. The system of claim 31, wherein the statistical representation of is expressed as:

$$S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$$

where,

β is a coefficient;

F_k is the difference between the current data point and predicted values for wafer k; and

Δ_k is a feedback value for time k.

38. The system of claim 37, wherein the value of Δ_k is calculated as:

$$\begin{aligned} &if\,|F_k - \Delta_k| \le K_n s_k \\ &\quad \Delta_{k+1} = \lambda_k F_k + (1-\lambda_k)\Delta_k \\ &else \\ &\quad \Delta_{k+1} = \Delta_k \end{aligned}$$

where, λ_k is a coefficient;

K_n is an outlier coefficient; and

$s_k = \sqrt{S_k}$.

39. The system of claim 39, further comprising:

means for updating S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$ when the current data point is determined as not an outlier.

40. The system of claim 37, further comprising:

means for updating S_k as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

41. The system of claim 37, further comprising:

means for updating S_k as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1-\beta)S_{k-1}$; and then

means for updating S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$, when the current data point is determined as not an outlier and the previous data was not determined as an outliner.

42. The system of claim 31, further comprising:

means for making a plurality of measurements on the output of the tool using at least one metrology station; and

means for calculating the current data point based on the plurality of measurements.

43. The system of claim 42, further comprising:

means for calculating an interval based on statistical information relating to the plurality of measurements;

means for identifying a subset among the plurality of measurements that fall within the interval; and

means for calculating the current data point from the subset of the plurality of the measurements.

44. The system of claim 43, wherein the statistical information relates to at least one of a median and a standard deviation of the plurality of measurements.

45. The system of claim 44, further comprising:

means for calculating the standard deviation based on one of a variance and a scaled variance of the plurality of measurements.

46. A computer readable medium for storing instructions being executed by one or more computers, the instructions directing the one or more computers for controlling a semiconductor manufacturing tool using a feedback control mechanism, the instructions comprising implementation of the steps of:

(a) receiving a plurality of data points relating to an output of the tool including a current data point and at least one previous data point;

(b) determining whether the current data point is an outlier based on:

(b-1) comparing the current data point to a statistical representation of the at least one previous data point; and

(b-2) whether the at least one previous data point is an outlier; and

(c) disregarding the current data point in calculating a feedback value of the feedback control mechanism if the current data point is determined as an outlier.

47. The method of claim 46, further comprising:

determining the current data point as an outlier only if the at least one previous data point is an outlier.

48. The medium of claim 46, further comprising:

(d) calculating the feedback value of the feedback control mechanism using the current data point and the at least one previous data point if the current data point is determined as not an outlier.

49. The medium of claim 46, further comprising:

(d) calculating a previous feedback value for the at least one previous data point and then calculating the feedback value based on the previous feedback value and the current data point if the at least one previous data point is an outlier and the current data point is an outlier.

50. The medium of claim 46, wherein the statistical representation of (b-1) is a weighted moving average of the at least one previous data point.

51. The medium of claim 46, wherein the statistical representation of (b-1) is an exponentially-weighted moving average of the at least one previous data point.

52. The medium of claim 46, wherein the statistical representation of (b-1) is expressed as:

$$S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$$

where,

β is a coefficient;

F_k is the difference between the current data point and predicted values for wafer k; and

Δ_k is a feedback value for time k.

53. The medium of claim 52, wherein the value of Δ_k is calculated as:

$$\begin{aligned} &if \left|F_k - \Delta_k\right| \le K_n s_k \\ &\quad \Delta_{k+1} = \lambda_k F_k + (1-\lambda_k)\Delta_k \\ &else \\ &\quad \Delta_{k+1} = \Delta_k \end{aligned}$$

where, λ_k is a coefficient;

K_n is an outlier coefficient; and

$s_k = \sqrt{S_k}$.

54. The medium of claim 52, further comprising:

updating S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$ when the current data point is determined as not an outlier.

55. The medium of claim 52, further comprising:

updating S_k as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

56. The medium of claim 52, further comprising:

updating S_k as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1-\beta)S_{k-1}$; and then

updating S_k as $S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$, when the current data point is determined as not an outlier and the previous data was not determined as an outliner.

57. The medium of claim 46, further comprising:

making a plurality of measurements on the output of the tool using at least one metrology station; and

calculating the current data point based on the plurality of measurements.

58. The medium of claim 57, further comprising:

calculating an interval based on statistical information relating to the plurality of measurements;

identifying a subset among the plurality of measurements that fall within the interval; and

calculating the current data point from the subset of the plurality of the measurements.

59. The medium of claim 58, wherein the statistical information relates to at least one of a median and a standard deviation of the plurality of measurements.

60. The medium of claim 59, further comprising:

calculating the standard deviation based on one of a variance and a scaled variance of the plurality of measurements.

61. A system of manufacturing semiconductor devices using a feedback control mechanism, comprising:

at least one processing tool configured to perform at least one semiconductor fabrication step on at least one wafer;

at least one metrology station coupled to the at least one processing tool and configured to make measurements on the at least one wafer;

an estimator configured to receive a plurality of data points relating to an output of the at least one tool including a current data point and at least one previous data point calculated base on the measurements made by the at least one metrology station,

wherein the estimator is further configured to determine whether the current data point is an outlier based on comparing the current data point to a statistical representation of the at least one previous data point, and whether the at least one previous data point is an outlier, and

wherein the estimator is further configured to disregard the current data point in calculating a feedback value of the feedback control mechanism if the current data point is determined as an outlier.

62. The system of claim 61, wherein the estimator is further configure to determine the current data point as an outlier only if the at least one previous data point is an outlier.

63. The system of claim 61, further comprising:

an optimizer coupled to the estimator to receive the feedback value and configured to generate at least one control parameter for operating the at least one tool based on the feedback value.

64. The system of claim 61, wherein the at least one tool is an etcher.

65. A method of controlling a semiconductor manufacturing tool using a feedback control mechanism, comprising:

(a) receiving a plurality of data points relating to an output of the tool including a current data point, a subsequent data point, and at least one previous data point;

(b) determining the current data point as an erroneous outlier:

(b-1) if a difference between the current data point and a predicted value, which is calculated from a statistical representation of the at least one previous data point, is outside of a threshold;

(b-2) if the at least one previous data point is not an outlier; and

(b-3) if the subsequent data point is not an outlier; and

(c) disregarding the current data point in calculating a feedback value of the feedback control mechanism if the current data point is determined as an erroneous outlier.

66. The method of claim 65, wherein the statistical representation of (b-1) is an exponentially-weighted moving average of the at least one previous data point.

67. The method of claim 66, wherein the statistical representation of (b-1) is expressed as:

$$S_k = \beta(F_k - \Delta_k)^2 + (1-\beta)S_{k-1}$$

where,

β is a coefficient;

F_k is the difference between the current data point and predicted values for wafer k; and

Δ_k is a feedback value for time k.

68. The method of claim 67, wherein the threshold is calculated as:

$$|F_k - \Delta_k| \leq K_n s_k$$

where, λ_k is a coefficient;

K_n is an outlier coefficient; and

$s_k = \sqrt{S_k}$.